



EVOLUTION

* Evolutionary Biology - study of history of life forms on earth.

* Changer in $\left\{ \begin{array}{l} \text{flora} \\ \text{fauna} \end{array} \right\}$ occurred \rightarrow over millions of years on earth.

* Story of ^①origin of life
^②evolution of life forms/biodiversity on earth

in $\left\{ \begin{array}{l} \text{context of} \\ \text{against the} \end{array} \right\}$ evolution of earth
 background of evolution of universe itself

ORIGIN OF LIFE

When we look at stars \rightarrow we look back at time

Stellar distances are measured in \rightarrow Light years

took millions of yrs to come

* Universe \rightarrow Vast

Earth \rightarrow speck

\rightarrow very old

\rightarrow 20 billion yrs old.

\rightarrow comprised of - Huge clusters of Galaxies contain \rightarrow Stars
 Clouds of $\left\{ \begin{array}{l} \text{① gas} \\ \text{② dust} \end{array} \right\}$

Big Bang Theory

attempts to explain Origin of Universe

\rightarrow singular huge explosion (unimaginable in physical terms)

\downarrow Universe expanded

\downarrow Temp. $\downarrow \downarrow$

\rightarrow $\left\{ \begin{array}{l} \text{① } H_2 \\ \text{② } He \end{array} \right\}$ formed sometime later

Gases condensed under gravitation

Formed galaxies of present day universe

Milky Way Galaxy - formed 4.5 billion yrs back.

* On ^{early} earth — no atmosphere

* Water mass that covered earth released

- H_2O vapour
- CH_4
- CO_2
- NH_3



* UV rays (from sun) broke H_2O into H_2 and O_2

lighter H_2 escaped.

* Ozone layer was formed *

combined with NH_3 & CH_4 to form CO_2 , H_2O (water) and others

* As it cooled (atmosphere) Water Vapour fell as Rain

Ocean. ← from depressions ← to fill

* NCERT THREAD NOTES

* Life appeared → 500 million yrs after formation of earth
4 billion yrs back ← i.e.

* Some scientists believed Life came from outside

9.5 billion yrs back

* Early Greek thinkers thought Units of life — spores

different planets (including earth) transferred to

PANSPERMIA still favourite idea of some astronomers

* For a long time considered Life came from decaying rotting straw mud.

THEORY OF SPONTANEOUS GENERATION

* LOUIS PASTEUR → dismissed

Careful Experiments — demonstrated LIFE comes from PRE-EXISTING LIFE

in pre-sterilised flasks

life did not come from killed yeast

Didn't answer — how first life forms came on earth!

crustaceans - Bat

archaea

Opabin from Russia
Haldane from England

proposed that

First life forms

said

Formation of life
was preceded

↓ by

chemical evolution

(i.e. formation of diverse organic molecules
↓ from
inorganic constituents)



Date
Page

could have come from

Pre-existing non living
Organic molecules

① RNA

② protein

* Conditions on earth were

→ high temp

→ Volcanic storms

→ Reducing Atmosphere

having

CH₄

NH₃

* 1953

S. L. Miller

created

Same conditions

in Laboratory scale

American scientist

created

Electric Discharge

$\xrightarrow[m]{a}$

closed flask

Contain

CH₄

H₂

NH₃

-ing

Water
vapour

2 : 2 : 1
↑ ↑ ↑
CH₄ : H₂ : NH₃

800°C

at

→ Observed : Formation of amino acids

glycine

alanine

aspartic acid

* In similar experiments, others observed → Formation of

* sugars * Nitrogenous base * Fats * Pigments

* Analysis of Meteorite Content $\xrightarrow[\text{revealed}]{440}$ similar comp.

Similar process occurring elsewhere in space ← indicating

- * With this limited Evidence — Chemical Evolution accepted
- * No idea — how self replicating metabolic capsules of life arose

* 1st NON-CELLULAR life forms origin → 3 billion yrs back

They would have been Giant Molecules → RNA, protein, polynucleotide

* These capsules → reproduced their molecules perhaps

* 1st CELLULAR life forms origin → 2 billion yrs back (2000 million)

probably — single-cells

* All life forms were in → Water environment only

This Version of BIOGENESIS i.e. first form of life

Non-living molecules ← from evolutionary forces ← through slowly → arose

→ accepted by majority !!

EVOLUTION OF LIFE FORMS - THEORY

* Conventional Religious Literature tells → THEORY OF SPECIAL CREATION

3 corollaries

Living organisms (species/types) that we see created as such.

Quantity was always the same since creation & will be same in future

Earth is 4000 yrs old.

strongly challenged in 19th century.

Charles Darwin

Sea Voyage

Sail ship

MS Beagle

round the world.

concluded.

Existing living forms

share similarities to varying degrees

with life forms that existed million of yrs ago.

among themselves

Many such life forms do not exist anymore.

Gradual evolution of earth

There had been extinctions of different life forms

New life forms arose a different periods of history

Years gone by

* Any population has built-in variations in characteristics

such natural conditions

to survive in

outbreed

others that are less endowed

would

enable some to survive better in natural conditions

climate

food

physical factors

* FITNESS OF THE INDIVIDUAL/POPULATION — accⁿ to Darwin refers ultimately & only Reproductive Fitness

More progeny than others.

leave

Those better fit in an environment

Hence

These therefore will survive more

&

Selected by the nature.

Mechanism of Evolution.

implied

NATURAL SELECTION

Darwin called it

ALFRED WALLACE

A naturalist

Worked in — Malay Archipelago

→ His theory :

→ had some similar conclusions as Darwin.

- * In due course of time, apparently new organisms are recorded.
- * All existing life forms, share → similar → common ancestor

- * These ancestors, were present at different periods in history → epochs, period, eras

ERA → PERIOD → EPOCHS → AGE

- * Geological history of earth closely correlates with Biological history of earth

- * Common permissible conclusion → Earth is very old (not thousands) but billions of yrs old.

WHAT ARE EVIDENCES FOR EVOLUTION?

- (1) **Fossils** → Remains of hard parts of life forms
→ Found in — Rocks, fossils → sediments

- * Cross section of Earth's crust indicate → Arrangement of sediments one over the other. → Long history of earth

- * Different-aged rocks & sediments contain fossils of different life forms
↓ who
probably died during formation of the particular sediment

Appear similar to modern organism

Some of them.

→ Figure represents extinct dinosaurs

- * A study of fossils in different sedimentary layers indicate → Geological period in which they existed

udy showed -
★ Life forms varied over time
★ Certain life forms - restricted to certain geological time spans.
→ Hence, New life forms have arisen at different times in history of Earth

ALL THIS IS - PALEONTOLOGICAL EVIDENCE

(2) EMBRYOLOGICAL SUPPORT FOR EVALUATION

→ Proposed by - Ernest Haeckel.

→ Based on - observation of certain features during embryonic stage common to all vertebrates that are absent in adults.

Eg → Embryos of all vertebrates including human

head ← just behind A row of vestigial gill slits ← develop

but → It is functional in → Fish & not found in any other adult vertebrate

Disapproved by - KARL ERNST VON BAER
↓ noted

Embryos never pass through adult stages of other animals.

(3) Comparative ANATOMY & MORPHOLOGY show similarities / differences among organism of today & those that existed yrs ago.

→ Such similarities can be interpreted to understand whether common ancestors were shared or not.

DIVERGENT EVOL.

Structures are - Homologous
Homology indicates common ancestry

CONVERGENT EVOL.

Structures are - Analogous

① Whales, Bats, cheetah, Humans (All mammals)

Share similarities in the patterns of bones of forelimbs

These forelimbs perform different functions in these animals

They have similar anatomical struct.

- ① Humerus ② Radius ③ Ulna ④ Carpals ⑤ Metacarpals ⑥ Phalanges in their forelimbs

* Hence, in these animals
↓
same structure
↓ developed along different directions
↓ due to
adaptations to different needs

② Vertebrate hearts or Brains

③ In plants,

thorns — Bougainvillea
tendrils — Cucurbita

① Wings of

Butterfly, Birds

look alike

but not anatomically similar though perform same function

* Different structures
↓ evolving for
same function
↓ hence having
similarity

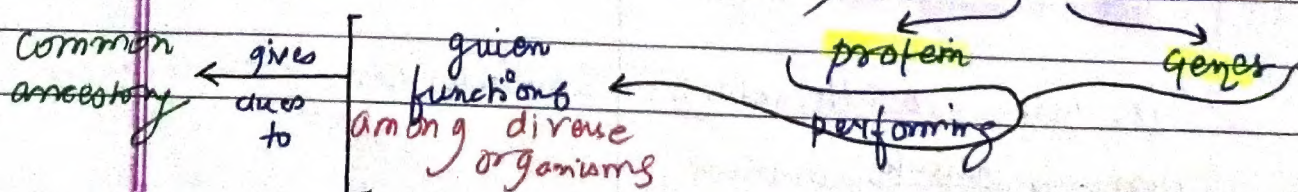
② Eye of octopus, mammals

③ Flippers of Penguins, Dolphins

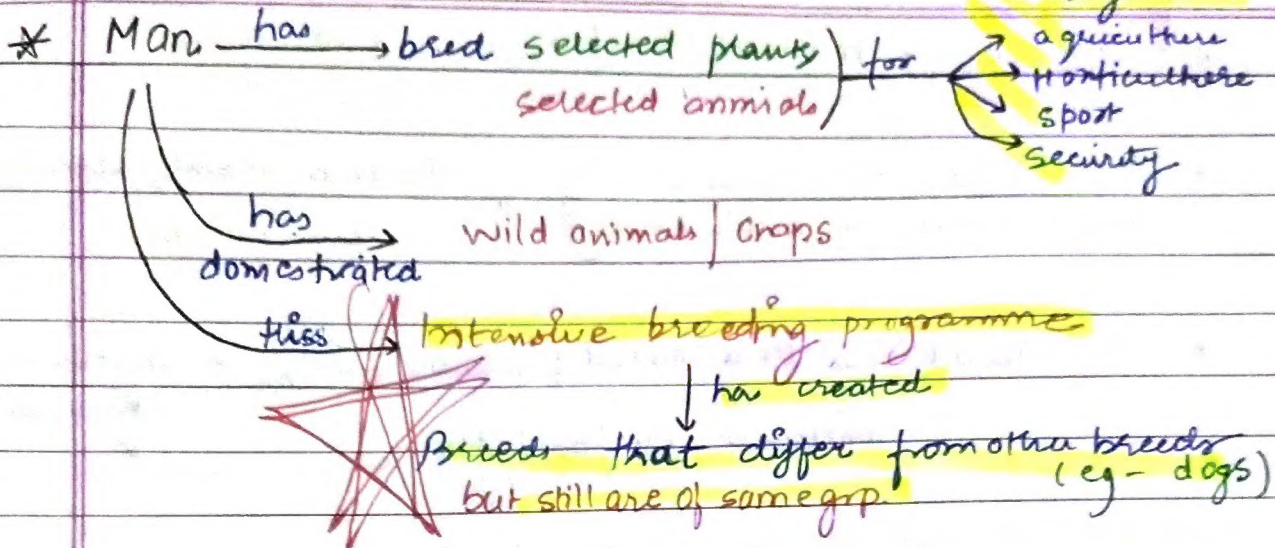
④ Sweet Potato (Root modification), Potato (Stem modification)
analogy.

* Similar habitats resulted in
selection of similar adaptive features in different groups of organisms
but
towards same function.

* In same line of argument, similarities in



biochemical similarities point to same shared ancestry or structural similarities among diverse organisms



* Argued - Man could create new breeds in 100's of yrs ?
Nature could not do it in millions of yrs

(3) Supporting Natural Selection Evolution From - England

* In collection of made, 1850's (before industrialisation) in moths

On trees : White winged moths

it was observed

Dark winged / Melanised moths

* After industrialisation in 1920

On trees : Dark winged moths

White winged moths

Proportion reversed

EXPLANATION - Predators will spot a moth against contrasting background.

* Post industrialised, tree trunks → dark

White winged moth did not survive to predators

under this cond.

due to industrial smoke soot

* Before industrialisation → thick growth of white lichens
 white winged moth hence survived ← trees ← covered

* Lichens — industrial pollution indicators

* Areas where industrialisation doesn't occur eg. RURAL AREAS → Melanic moths were low in no.

* This showed → In a mixed population those can better adapt survive
 increase in population size

* NO VARIANT IS COMPLETELY WIPE OUT !!!

Excess use of ① herbicides ② pesticides } has resulted in selection of resistant varieties in much lesser time scale

“Microbes” against which we employ ① antibiotics ② drugs against eukaryotic organisms / cell.
 TRUE FOR

HENCE
 Resistant organism/cell appearing in a time scale of months → years (NOT centuries)

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 Eg. of → EVOLUTION DUE TO ANTHROPOGENIC ACTION

This also tells, EVOLUTION is not directed process in the sense of determinism
 it is STOCHASTIC PROCESS (based on chance events in nature → chance mutation in the organism)

WHAT IS ADAPTIVE RADIATION

Darwin $\xrightarrow{\text{went to}}$ Galapagos Islands $\xrightarrow{\text{he observed}}$ amazing diversity of creatures.

On particular \rightarrow Small Black birds (Later called as Darwin's Finches) \rightarrow there were many varieties of FINCHES in some island.

Original Seed Eating features \leftarrow from All varieties he conjectured evolved on the island itself.

Many other forms arose with ALTERED BEAKS enabling Insectivorous & Vegetarian finches.

ADAPTIVE RADIATION \rightarrow Process of evolution of different species in a given geographical area

Other areas of geography (Habitat) \leftarrow to radiating \leftarrow & literally point \leftarrow starting from a

Perfect example - Darwin's Finches

Another example - AUSTRALIAN MARSUPIALS

but all within Australian Island continent

Ancestral Stock $\xleftarrow{\text{evolved from}}$ each different from other

* When more than one (>1) adaptive Radiation

\downarrow appeared to have

occured

\downarrow in an

Isolated Geographical Area

(representing different habitats)

called as

CONVERGENT EVOLUTION

* (Placental mammals \xrightarrow{in} Australia) \rightarrow also exhibits ADAPTIVE RADIATION

Varities of such placental mammals

$\xleftarrow{\text{in evolving into}}$

each of which \rightarrow appears similar to a corresponding marsupial

(PLACENTAL WOLF \rightarrow TASHANIAN WOLF MARSUPIAL)

* There is Convergent Evolution of Australian Marsupials & Placental mammals

BIOLOGICAL EVOLUTION



Date

Page

Evolution by Natural Selection in true sense would have started when cellular forms of life differences in metabolic capability originated on earth.

* Essence of Darwinian Theory about Evolution → NATURAL SELECTION

* Rate of appearance of new life forms is linked to life cycle / life span

* Microbes that divide fast have ability to multiply & become millions of individuals within hrs

Colony (A) (of Bacteria)

growing on given medium

has built-in-variation

in terms of ability to utilise a feed component

change in medium would bring out

Colony / Population (B)

that can survive under new condition

outgrows

This variant population

during the course of time

others & appear

as new species

this would happen

Within Days

* For same thing to happen in ① Fish ② Fowls it would take millions of years (as life span of these animals are in years)

* Here we say Fitness of B > A under new condition (better)

- * Nature ~~selects for~~ fitness is based on characteristics which are inherited -
- * Hence, there must be Genetic Basis ~~for~~ getting selected & to evolve

- * Some organisms are better adapted to survive in an otherwise hostile environment

- * Adaptive ability \xrightarrow{is} inherited
 \searrow has Genetic basis

- * Fitness \xrightarrow{is} end result of \rightarrow ① ability to adapt & survive.
 ② (get selected by nature)

- * 2 key concepts of "Darwinian Theory of Evolution"
 - \rightarrow Branching descent
 - \rightarrow Natural selection

- * Before Darwin

LANARCK

French Naturalist

\rightarrow said - Evolution of life forms had occurred
 but driven by - [USE & DISUSE OF ORGANS]

Eg - GIRAFFE \rightarrow in attempt to forage leaves on tall trees

\downarrow had to adapt

elongation of their necks

\rightarrow they passed on this acquired character of elongated neck to succeeding generations
 \downarrow
 Giraffe's acquired long necks

Nobody believes this conjecture anymore

- * When we discuss "Story of this world" we describe \rightarrow evolution as a process

- * Or, when we describe the "Story of life on Earth" we describe \rightarrow Evolution as a consequence of process - NATURAL SELECTION

Possible -

Work of THOMAS MALTHUS

influenced Darwin

↓ on
Populations



Date

Page

1) Natural selection $\xrightarrow[\text{is based on}]{}$ certain observations $\xrightarrow[\text{are}]{\text{which}}$ factual

Eg. Natural resources - are limited

Populations \rightarrow stable in size $\xrightarrow[\text{for}]{\text{except}}$ seasonal fluctuation

Members of population $\xrightarrow[\text{in}]{\text{vary}}$ characteristics (in fact no two individuals are like)

even though they look superficially similar

most of variation are inherited

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AIR 1747

NCERT THREAD NOTES

Fact that, theoretically population size will grow $\xrightarrow[\text{fact that}]{\text{if everybody reproduced maximally}}$ Population sizes in reality are limited

There had been "COMPETITION FOR RESOURCES"

* Novelty & Brilliant insight of Darwin $\xrightarrow[\text{asserted}]{\text{he}}$ Variations, which are heritable

(which makes) resource utilisation better for few (adapted to habitat better)

leave more progeny \leftarrow reproduce \leftarrow will enable only those to

* Hence, for a period of time \rightarrow Over many generations

New forms appear \leftarrow change in population characteristic \leftarrow there would be survivors with more progeny

MECHANISM OF EVOLUTION

Darwin \rightarrow ignored Mendel's inheritable factors influencing phenotypes

* In 1st decade of 20th century, \rightarrow Hugo De Vries $\xrightarrow[\text{work of}]{\text{based on}}$ Evening Primrose

population $\xrightarrow[\text{in}]{\text{differing suddenly}}$ large differences \leftarrow Mutation

Believed - Mutations causes Evolution

& not minor variations (heritable)
Darwin said

Mutations

- * Random
- * Directionless
- * De Vries believed
↓
Mutation
↓ caused
speciation
↓ hence called
SALTATION
(single step large mutation)

Darwinian Variations

- * Small
- * Directional
- * Evolution for Darwin
↓
Gradual

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NCERT THREAD NOTES

HARDY-WEINBERG PRINCIPLE

In a given population \longrightarrow one can find out frequency of occurrence of alleles of a gene or a locus

* Frequency $\xrightarrow[\text{is supposed to be}]{\text{is}}$ remain fixed

even remain same throughout generations

\longrightarrow stated it using algebraic equations.

* Principle Says — Allele frequency in a population are stable & is constant from generation to generation

OR

GENETIC
EQUILIBRIUM.

Gene pool (① total genes & ② their alleles in a population)

remains constant.

Sum total of all the allelic frequencies is 1.

★ Individual frequencies $\rightarrow p$
 $\rightarrow q$

• In a diploid, p & q represent the frequency of alleles A & a
[probability that an allele 'A' with a frequency 'p' appear on both the chromosomes of a diploid individual is simply product of probability, i.e. p^2]

* Frequency of $aa - q^2$

* Frequency of $Aa - 2pq$

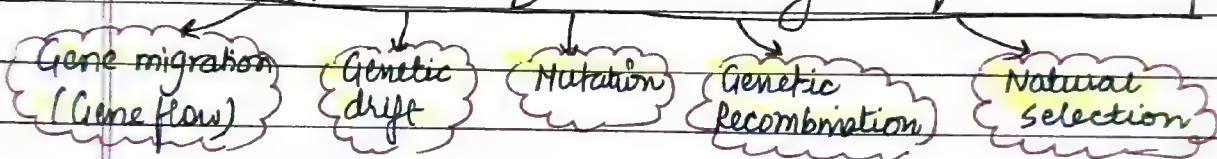
$$p^2 + 2pq + q^2 = 1$$

★ When frequency measured, differs from expected values

The difference (direction) \rightarrow indicates the extent of evolutionary change.

* Disturbance in genetic equilibrium, (Hardy Weinberg Equilibrium) change of frequency of alleles in a population, would then be interpreted as resulting in evolution.

5 factors affect Hardy Weinberg Equilibrium



1) **Gene Migration** — When migration of a section of change population to another place, occurs, gene frequencies change in the \rightarrow original population \rightarrow New population

If gene migration happens, multiple times

Gene flow

New genes/alleles are added to new population & these are lost from old population

2) **Genetic Drift** — If "gene migration" occurs by chance.

Original drifted population
Founders


Sometimes, change in allele frequency is so different

new sample of population that they become

Effect \rightarrow Founders Effect.

Different species

Microbial Experiments show that pre-existing advantageous mutations

Observation of new phenotypes will result in  Date _____ Page _____

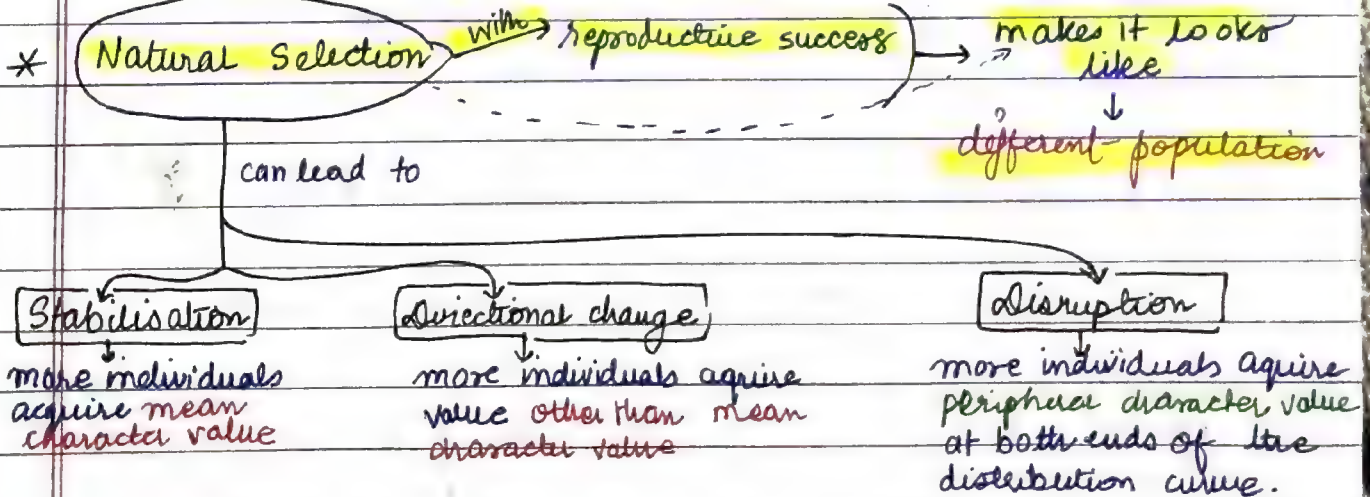
Over few generations this would result in SPECIATION

* **NATURAL SELECTION** → process in which heritable variations enabling better survival are enable to reproduce & leave greater no. of progeny.

* A critical analysis, makes us believe that variation due to

mutation
Recombination (during gametogenesis)
Gene flow
genetic drift

changed frequency of genes/alleles in future generation ← results in



A BRIEF ACCOUNT OF EVOLUTION

* About 2000 mya (million years ago) → 1st cellular form of life appeared on earth.

* Mechanism of how non-cellular aggregates of giant macromolecules, could evolve into cells with membranous envelop is } not known.



Date

Page

* Some of these cells $\xrightarrow{\text{had ability}}$ to release $O_2 \uparrow$.


* The skin $\xrightarrow[\text{have been}]{\text{could}}$ similar to the light-reaction in photosynthesis where water is split with help of solar energy captured & channelised by appropriate light harvesting pigments.

* Slowly, single celled organisms $\xrightarrow{\text{became}}$ multicellular life forms.

* By 500 mya \longrightarrow Invertebrates were formed & active

* By 350 mya \longrightarrow Jawless fishes evolved

* Around 320 mya $\xrightarrow{\text{sea weeds \& few plants}}$ existed

* First organisms, that invaded land — Plants 

They were widespread on land when animals invaded land.

* Around 350 mya \longrightarrow Fish with stout & strong fins could move on land & go back to water.

* In 1938 \longrightarrow Fish caught in South Africa was a Coelacanth (which was thought to be extinct)

evolved into

LOBEFINS

FIRST AMPHIBIANS

(lived on both land & water)

No specimens left today



Ancestors of

modern day frog

Salamanders

* Amphibians evolved into **Reptiles** lay **thick shelled eggs** (did not dry up from sun like that of amphibians)



Date
Page

We only see modern day descendants

- Turtles
- Tortoises
- Crocodiles

* Nent 200 million years or so — Reptiles of different shapes & size dominated on earth.

* Giant ferns (Pteridophytes) were present but they all fell to form coal deposits slowly

* Probably 200 million years ago (mya) — Some of land reptiles went back into water to evolve into **Fish like reptiles** (Ichthyosaurs)

* Land Reptiles were **Dinosaurs** (Ichthyosaurs)

Biggest of them — **TYRANNOSAURUS REX**

20 feet in height
huge daggerlike teeth
fearsome

65 mya
Dinosaurs suddenly disappeared from earth

(1) climatic change may have killed them
(2) Most of them evolved into Birds
Real reasons are not known
Truth may lie in between

* Small sized Reptiles of that era still exist today

* First mammals were like **Shrews** — their fossils were small sized

* Mammals were

- Viviparous
- protected the unborn young inside mother's body
- were intelligent in sensing & avoiding danger at least.
- took over when Reptiles came down.

* South American Mammals

resembling

Horse

hippopotamus

Bear

Rabbit



Date

Page

* due to Continental Drift

pouched

mammals

of Australia survived

Lack of competition from other mammals

be of

* Mammals who live wholly in water

whaler

Dolphins

Seals

Sea cows

* Most successful story

Evolution of Man

with

Language skills

Self-consciousness

ORIGIN & EVOLUTION OF MAN

(*) About 15 mya, primates

→

DRYOPITHECUS

RANAPITHECUS

} were existing

~~hairy~~

they were

walked like

gorillas

chimpanzee

(*) RANAPITHECUS - More man-like

(*) DRYOPITHECUS - More ape-like

(*) Few fossils of man-like bones

have been

discovered in

→ Ethiopia

→ Tanzania

↓ this revealed

Homonid features leading to belief

3-4 mya, man-like primates

walked in EASTERN AFRICA

→ not taller than 4 feet

walked upright



Date

Page

* 2 mya → **AUSTRALOPITHECINES** → lived in East African Grasslands

hunted with the stone weapons

essentially, ate fruits

* Some of the bones, among bones discovered were different

HOMO HABILIS

1st human like being
Hominid

This creature was

Brain capacities - 650 - 800 cc

did not eat meat

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NCERT THREAD NOTES

* Fossils discovered in 1891 (Java)

revealed next stage

HOMO ERECTUS

* ate meat *

Brain capacities
900 cc

appeared around 1.5 mya

NEANDERTHAL MAN

Brain size - 1400 cc

Lived near (east central) Asia

used hides to protect their body

b/w 1,00,000 - 40,000 yrs back

buried dead

HOMO SAPIENS

* rose in Africa *

spread across continents & developed into races *

MODERN HOMO SAPIENS

Rose in - Ice age

(b/w 75,000 - 10,000 yrs ago)

* Pre historic Cave art developed in 18000 yrs ago

* One such Cave Art / painting seen at Bhimbetka Rock Shelter

Raisen district, Madhya Pradesh.

in

- * Agriculture came 10,000 yrs back.
 ↳ human settlements started
- * Rest of what happened is part of human history of Growth & decline of civilisation

- * Origin of life on Earth can be understood only against the Background of origin of Universe (especially earth)

- * Darwinian ideas were of organic evolution by natural selection

- * Variations in population results in Variable fitness

- * ① Habitat Fragmentation may accentuate these variation
 ② Genetic Drift leading to appearance of new species

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- * Homology is accounted for by the idea of branching descent.

- * Study of comparative anatomy fossils Biochemistry provides evidence for evolution

- * Story of Evolution of Modern Man appears to be Parallel evolution of human brain language

- Q. Can we call human evolution as adaptive Radiation?
 No.

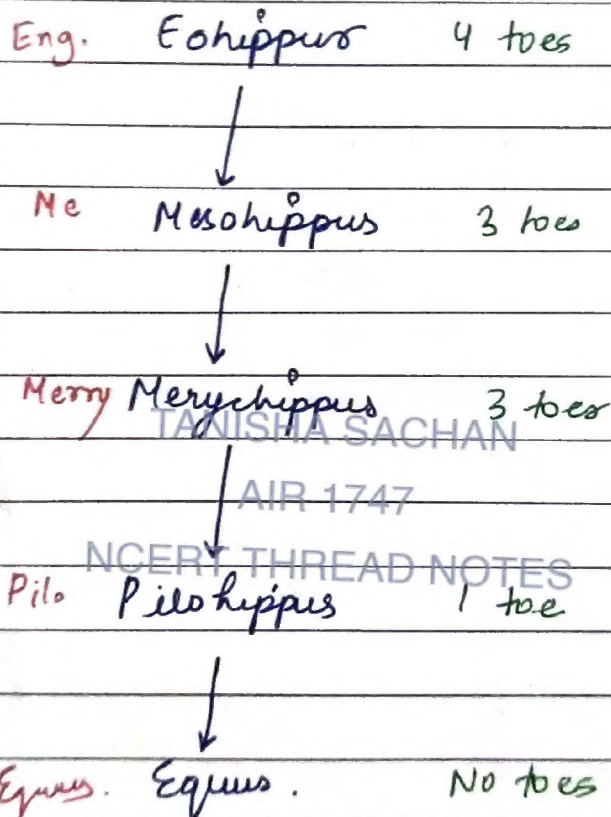
- Q. List 10 modern day animals & using the internet resources link it to a corresponding ancient fossil. Name both.

Horse -	Eohippus
Man -	Ramapithecus
Whale -	Protocetus
Elephant -	Moeritheres
Dog -	Leptacyon
Camel -	Protylopus
Tetrapods -	Ichthyospora
Bat -	Archaeonycteris

Date _____
Page _____
Taxonomic Hierarchy of Horse

S - E. ferus
G - Equus
F - Equidae
O - Perissodactyla
C - Mammalia
P - Chordata
K - Animalia

Evolutionary stages of Horse



Evolution of horse has caused
some toes on the horse leg
to shorten ultimately disappeared.